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REVIEW ARTICLE

Cone beam-computed tomography applications in endodontics: A review

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Abstract

Administering complicated endodontics treatments call for considerable operational accuracy as well as accurate tools and imaging. Hence, the objective of this study is to evaluate cone beam-computed tomography (CBCT) functionality as a high resolution imaging technique in endodontics. In this review study, articles were sought at authorized e-sources including Google scholar, Chochrane, Science Citation Index, Medline, Iran Medex, and Scopus. These articles were compiled using keywords such as CBCT imaging, endodontics, vertical root fracture, and periapical lesion. Reviewing the articles, we have seen that CBCT could be used for a diagnosis of periapical lesions and its healing process, tooth morphology and its complications, such as sub canal and canal curvature, traumatic injury, inside and outside view of the tooth, root resorption defections, fracture lines, perforation, broken tools, UR fillings, calcified canal, root proximity, and pre-operation evaluation, that the conventional radiography is unable to perform. Since the CBCT suggests great accuracy and sensitivity, in the case that we could overcome the limitations (especially high demand), it can progress to the extent that in some occasions it can be used as the first dental imaging method.

Keywords: Cone beam-computed tomography imaging, endodontics, periapical lesion, vertical root fracture

Introduction

Radiographic evaluation is essential for performing endodontic treatment procedures such as correct diagnosis, providing appropriate treatment plan, controlling through work, and evaluation.[1] Today, radiographic evaluation in endodontics is confined to conventional intraoral and panoramic radiography.[2] Intraoral radiographies uncover useful information on the presence and location of periradicular lesions, root canal anatomy, and proximity of anatomic structures.[3] They have some limitations either, which could be due to two-dimensional nature of the provided images, geometric distortion, and anatomical overlapping or combination of the factors.[4] For instance, in periapical cliché frames significant tooth characteristics and its surrounding tissues could be seen in the mesiodistal plane (proximal) while similar features could be existed in buccolingual plane (three dimension [3D]) which are taken for granted.[5] Anatomical structures, which make field or structural noise (disorganization) could be apak (like zygomatic appendage) or lucent (like maxillary sinus and foramen snizio) that this complicated anatomy and its surrounding structures cause the shades to be interpreted with difficulty. And about image's geometric factors, what considered is radiographic enlargement and change of radiation angle that cause a difference in construction position.[5]

Cone beam-computed tomography (CBCT) made it possible to see dentition, SCET maxillofacial, and the connections of anatomical structures in 3D.[6]

In CBCT, the X-ray beam is conical and divergent with a detector spinning around the area of interest providing the data cylindrically (field of view [Fov]).[7]

Therefore, a field of view consisted of millions of voxels, all of which could be prepared in isotropic (with equal dimension) or anisotropic (with unequal dimension) shape and CBCT enjoys the former shape. Data are processed by computer, and the images are reconstructed in sagittal, axial, and coronal planes.[7]

The clinician can select the desired slice thickness;[8] these three planes are observable, simultaneously, and any alteration in one of the planes will change the other two at the same time.[8]

Fov dimensions depend on detector's size and shape, image geometric, and capability of radiation collision.[9] The smaller the Fov, the more resolution of the image and the smaller the required radiation.[10] Voxel heights depend on slice thickness showing the resolution of the reconstructed image.[10]

The use of limited Fov CBCT has priority over large volume CBCT in that periodontal ligament space is important in endodontics and integrated evaluation and the thickness is 200 μm,[11] unless in the case that extensive pathological development and apex that surround some teeth or a multi-canonical lesion are probable with systematic etiology or something other than endodontics has caused tooth vitality lost.[11]

The most significant limitation of CBCT is its artifacts which make the interpretation problematic.[12] These artifacts are in three categories: (1) Physical variation like beam, partial volume artifact, noise, hardening,[13] (2) those related to the patient, like Metallic streak, Motion artifact, artifacts, and (3) those related to the scanner performance.[14]

Administering complicated treatments in endodontics requires great work accuracy and accurate tools and imaging. Since CBCT(as a new imaging method in dentistry) is very much in vogue recently, the aim of this review article is to compile issues, which facilitate the endodontic treatment.

Materials and Methods

The study evaluated issues that their application in endodontics generally improves the treatment quality and helps the treatment process such as diagnosis, treatment plan, evaluations between the procedure and data analysis. Articles were sought using Chochrane, Medline, Google scholar, Science Citation Index, Iran Medex, and Scopus. These articles were published during 1999-2012 and were compiled using keywords such as CBCT, periapical lesion, vertical root fractures (VRF), endodontics, and imaging. Since the authors published some related research studies and articles in the field, they tried to gather the existing methods and conclude the results.

Results

Many related articles have been found by the keywords and after reviewing the articles appropriate researches have been conducted as to the desired study objectives. According to the existing evidence, it is seen that employing CBCT imaging methods have contraindications in some cases.[15] CBCT should not be used for a common endodontics diagnoses, screening objectives in cases with no clinical signs, and for pregnant and young people.[16] Moreover, CBCT cannot assess soft tissue lesions, unless in cases that they cause some alteration in hard tissue such as tooth and bone. In most cases medical CT scan on changes derived from tumor is due to the capability of observing more proper soft tissue.[17]

In general, employing CBCT in endodontics is limited to evaluation and the treatment of complicated endo cases as follows:

1. To determine the existence of periapical lesion and its healing process, as well as the extent of lesion spread and its effect on surrounding structures.[18] In most cases, the superimposition of teeth's root with a maxillofacial skeleton made the presence and spread of periapical lesion difficult.[19] It is seen that the prevalence of apical periodontitis in evaluation by CBCT is far higher than its prevalence in evaluations carried out by periapical or panoramic radiography.[20]
2. To assess the tooth and its related complications morphologically, like a curve in the root. Sub-canals and the existence of additional canal the lack of which is highly probable.[21] The existence of calcified canals[22] for investigating interior and the exterior surface of the tooth, for example, diagnosis of C-shaped pattern of the canal is difficult with conventional radiography.[23] To evaluate the traumatic injuries which cause root fracture, alveolar bone, or replacement of the tooth and its location[24] in CBCT imaging the tooth position and bone fracture are easily diagnosable.[25]
3. To evaluate the problems occur during the endo, like high or low root canal obturation, the presence and position of the fractured tool, and the place and spread of created root perforation.[26]
4. CBCT is useful for pre-operation evaluations. For instance, marking the accurate location of root apex and the proximity of the neighboring structures before apico operations,[27] as well as in implant cases for checking edentulous ridges, bone quality and density, and the place of significant anatomic landmarks like inferior alveolar nerve.[28]
5. To identify resorptional defections such as interior root resorption, exterior surface resorption, inflammation, cervical, or ankylosis cases with these imaging methods.[3] It facilitates right treatment plan and prognosis.[29]
6. CBCT can be used for the diagnosis of vertical root fracture line. VRF is a fracture line, which takes place along the long axis of the tooth and often created as a result of latrogenic injury during dentistry treatment.[30] In most cases, VRF will extend to periodontal ligament space and may cause the soft tissue to penetrate the fracture place and increase the gap between two dental parts and as time passes, some resorptional areas will appear in place.[30] VRF diagnosis is established through clinical signs such as pain, inflation, the existence of single deep periodontal pocket, sinus tract or sinus tract-like pockets in two different root areas along with radiographic signs such as loncilateral and periapical.[31] The most exploring operations were performed for observing fracture, and the process is done by providing flap and direct observation of fracture under lighting, enlargement, and methylene blue painting.[32]

The obtained results shown than the CBCT resolution for VRF diagnosis is far higher than periapical radiography.[31]

CBCT scanning resolution has been evaluated with various voxels of 4.0, 3.0, 2.0, and 125.0 mm and it is observed that 2.0 mm voxel with minimum radiation provides the best VRF diagnosis quality.[32]

In VRF diagnosis, axial images are considerably more accurate than sagittal and coronal ones.[31]

It is expected that CBCT variations could diagnose VRF faster, before bone and consequently tissue demolition occur.

Discussion

Although CBCT could raise the diagnosis possibility of the abovementioned issues, type of CBCT machine affects the resultant images. Hassan *et al.*, 2010, compared five CBCT systems for VRF diagnosis and concluded that CAT I and Scannora 3D are the most accurate devices, respectively.[33] He reported that what make these two machines different from other ones were their detectors. I-CAT and Scannora have image intensifier tube/charged coupled device while other three devices - namely, newtome, accuitomo, galileo - have flat-panel detectors (FPD), which cause decreased dynamic range, contrast, low spatial resolution, high image artifact.[33]

However, modern types such as VG and VG Newtom, in addition to FPD, enjoy smaller voxel size, which improves image quality and VRF diagnosis in this device substantially.

Nevertheless, Yousefzadeh claimed that the resultant metal artifacts of metal objects including metal posts lower image quality and VRF diagnosis sensitivity.[34] The most important drawback of CBCT is high radiation rate and cost.[35] There are some solutions to decrease the radiation rate, like the use of smaller Fov, which lowers radiation rate.[10] It has been observed that D Accuitoma 3 device with a minimum voxel size of (0.08 mm) requires similar radiation rate.[36] Similarly, as seen in a project, Kodak 9000 3D, could lower the required patient radiation 0.4-2.7 times of digital panoramic radiation.[37-39]

Conclusion

Since CBCT possesses high accuracy and sensitivity, in the case, we can circumvent its limitations (especially its high demand), it could make progress to the point that being considered as the first dental imaging method.

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